The applicant respectfully points out that the object of his US Patent No. 5,818,138 does not possess those characteristics the examiner describes in the response.

Hill ('138) describes a "permanent magnet electric machine". This is a type of machine that differs fundamentally from the type of machine of the present application in that the former's principle of functioning is based on permanent magnets.

The applicant respectfully explains that permanent magnets are also called hard magnets. Hard magnetic materials differ from soft magnetic materials by the shape of their hysteresis curve. The magnetic poles of soft magnetic materials can be easily reversed. Without any field intensity acting on them from the outside, they do not have any residual magnetism (remanence = 0).

On the other hand, it is very difficult to reverse the magnetic poles of hard magnetic materials. They preserve their magnetism, even if the source of field intensity acting from the outside is turned off (after magnetization). This residual magnetism is called remanence and magnetized hard magnetic segments are called permanent magnets.

As stated, Hill ('138) describes explicitly an electric machine with <u>hard</u> magnetic material. The segments marked **2** consist of a permanent magnet **4** and a soft magnetic body **3** (see col. 2, line 14 - 16). The operating principle of this machine is based on the hard magnets generating an energizing field and the currents in the winding generating forces by interacting with these permanently energized fields.

On the other hand, the object of the present application does not contain any hard magnetic material! Thus, there are no permanent excited magnetic fields in a machine in accordance with claim 1. The type of machine is clearly defined in claims 1, 6, and 7. Its characteristics are:

- Two structural groups containing at least one soft magnetic body each,
- partial areas of the surfaces of said at least two structural groups that lie adjacent to said air gap having **inhomogeneous properties** with regard to the magnetic flux,

- said region facing the air gap **having soft magnetic teeth** that are disposed toward said air gap.

From this, it is obvious to one skilled in the art that the air gap has on its two sides soft magnetic teeth - and not hard magnets. Hill ('138) shows in all figures permanent magnets (4, 8) in the air gap. The soft magnetic part of the rotor segments (3, 6) shows a smooth surface toward the air gap. Thus, the soft magnetic body of the rotor **does not** consist of teeth that are disposed toward the air gap.

Applicant respectfully points out that permanent magnets have a magnetic conductivity like air (relative permeability of approximately 1). Thus, for an external magnetic field, permanent magnets act practically like air. From this follows that the rotor in Hill ('138) does not have **inhomogeneous properties** and the magnetic resistance of electrically generated magnetic fields of the stator is constant.

In summary: Hill ('138) describes an electric machine with permanent magnets on a smooth soft magnetic surface of the rotor. This type machine is fundamentally different from the type of machine described in claims 1 and 6 of the present application.

An electric machine with permanent magnets (= a synchronous machine) is fundamentally different from an electric machine with soft magnetic teeth on both sides of the air gap (= a reluctance machine) and a person having ordinary skills in the art is aware of this. It is not possible to arrive at the solution presented in the current invention by modifying the electric machine of Hill ('138).

Rosenberry (US 4,392,072) does not either describe a machine that possesses soft magnetic teeth on both sides of the air gap and thus, inhomogeneity. Rosenberry shows in Fig. 2 an internal rotor with a smooth surface towards the air gap. Furthermore, the teeth shown in Fig. 2 have pole shoes. Pole

shoes close the grooves partially in order to keep the inhomogeneity of the air gap surface for the magnetic flux as small as possible.

The pole shoes are thus, for a person skilled in the art, a clear indication that is leading away from the present invention.

The applicant respectfully points out that amorphous metals are characterized by a distinctly lower saturation magnetization than crystalline electric sheet. The best amorphous metals achieve maximally 1.6 T!

This is borne out by Ray in US 4,036,638. There, in Table II, column 6, a saturation magnetization of 16.1 kGaus = 1.61 T is given for the alloy composition $Fe_{83}B17$ and $Fe_{80}B20$. An alloy composition with cobalt achieves only 10.8 kGaus = 1.08 T. To this day, these values have not changed.

A person skilled in the art knows that the saturation magnetisation of amorphous metals is lower than that of crystalline metals. Even regular electric sheet is very easily magnetizable up to 1.65 T and achieves a saturation magnetization of 1.9 to 1.95 T.

Amorphous metal is only available in very thin layers, which can not be punched. For this reason, Rosenberry suggests to produce the teeth by winding them up (Fig. 4 and Fig. 5). Attachment is problematic so that the amorphous metal is sealed in resin. However, epoxy resin does not conduct magnetic flux. The median saturation magnetization of the part is decreased by its share in the volume. Due to said resin, the teeth in Rosenberry have a lower saturation magnetization than the metal alone.

Amorphous material is mechanically less stable under load. It is therefore not well suited for reluctance machines with their strongly pulsating magnetic forces, or it will require much resin. Additionally, amorphous metal is noticeably more expensive than electric sheet. The objective of the present invention is to minimize the costs of the (reluctance) machine. Since Rosenberry constructs the entire stator of the expensive amorphous material, an approach for a solution would

not be obvious for one skilled in the art, which would lead to the solution of claim 1 or claim 6.

Rosenberry teaches also soft magnetic bodies formed of amorphous metal particles and a moulded bonding resin that fix the particles in a highly compacted relationship with a film resin separating a major portion of the particles from one another. This kind of soft magnetic body has, compared to a crystalline metal, a very high magnetic resistance, because each film of resin between the particles in direction of the magnetic flux increases the magnetic resistance.

Someone skilled in the art knows that materials with high magnetic resistance are not feasible for increasing the power density of a reluctance machine. Furthermore, the resin-bonded material is even more expensive. The particles are more expensive to produce than the thin ribbon.

In summary: There are four good reasons **not** to use Rosenberry's solution in reluctance machines

a) the lower maximum magnetic flux density of the material
b) the high price of the material
c) the complex processing properties of the material
d) the high magnetic resistance of resin bonded material.

Fanning shows in Fig. 6 - 8 a laminated stator comprising soft magnetic bodies stacked in tangential direction, and the thickness of the sheet increases as the radius increases.

Claim 4 of the present invention is dependent on claim 1. Fanning shows a totally different type of machine and not the features of claim 1.

Intermadox shows a stepping motor with a permanent magnet rotor and a stator that is laminated in axial direction, wherein said stator is composed of abutting annular sheet sectors (1) that are stacked in circumferential direction. The

annular sheet sector is a part that is punched in one piece from a sheet. In Fig. 1, this piece covers one fourth (90°) of the circumference. A wide pole in the center of the sheet sectors is arranged between two half poles that, at the air gap, are approximately half as wide.

Contrary to this state of the art, which has been known since June 1978, the soft magnetic body in claim 6 does not consist of multi-pole sectors, but of several individual parts. Pole segments and half pole segments are made as separate units. This additional separation of the soft magnetic body into smaller units results in the characteristic of "pole segments consisting of grain oriented material". This combination:

a) Separation of the punched sheet into smaller units (single pole segments)
b) Utilization of grain oriented material, which is not generally done in motors

is not shown by Intermadox.

These new characteristics provide considerable advantages.

1) At identical current in the pole coil, a 12% higher flux density can be realized at identical field strength in the teeth arranged at the air gap. Example: At a field strength of 2500 A/m, grain oriented material can achieve 1.85 T and non-oriented material only 1.65 T. Since flux density contributes quadratic to force generation, torque increases by 25%!
2) At identical flux density in the pole core between the grooves, losses of grain oriented material are 70% lower than those of non-oriented material. The efficiency of the motor can clearly increase, e.g. from 70 to 78%.
3) The coil can be wound tightly and very closely directly onto the pole core. The higher space factor lowers the losses in the winding.

The applicant names 3 reasons for patentability of claim 6:

- An increase of power density by more than 20% and concurrently clearly decreased losses are considerable improvements in electric machines.
- The state or the art is already 20 years old.
- The objective - increase of power density and reduction of losses - has occupied many persons in the past 20 years. Nevertheless, the combination of characteristics a) and b) in claim 6 are new.

None of the documents - Hill ('138), Rosenberry, and Intermadox - show the characteristics of claim 1 and claim 6 of the present invention.

Reconsideration and allowance of the application is respectfully requested.

Respectfully submitted,

W. Hill

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